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Full Length Research Paper

An examination of preschool prospective teachers' subject matter knowledge and pedagogical content knowledge on basic geometric shapes in Turkey

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The purpose of this study is to examine preschool preservice teachers' subject matter knowledge (SMK) and pedagogical content knowledge (PCK) of basic geometric shapes. The study employed case study method in order to investigate preschool preservice teachers' SMK and PCK on geometric shapes in actual classroom environment and to describe the situation in-depth. The study group was composed of two senior year students studying at the department of preschool teaching at a state university. Triangulation was employed in order to improve the validity, and the data of the study were obtained from semi-structured interviews, lesson plans prepared by the propective teachers, and video recordings of teaching practice lessons. The results of the study showed that preservice teachers had some problems when describing geometric shapes and they did not use the mathematical language effectively. One of the preservice teachers was observed to have combined the new information with the children's prior learning. Both preservice teachers tried to teach geometric shapes by referring to daily life in order for students to understand the shapes better, and one of the preservice teachers also employed activities involving visual aids. The participants were found not to be fully informed about the possible student's misconceptions. One of the preservice teachers mentioned alternative evaluation methods for evaluating students' learning while the other preservice teacher did not mention these methods. Based on the results, it is suggested that when preservice teachers are being taught they should acquire SMK and PCK more effectively, and they should be provided with environment where they can implement what they learn.

Key words: Preschool prospective teachers, subject matter knowledge, pedagogical content knowledge, basic geometric shapes.

INTRODUCTION

Experiences gained during pre school period make up the basis of more complex concept learning that will be acquired in the future, and also play an important role in children's success (Clements and Samara, 2004 cited in Aslan, 2004). Students usually learn geometric concepts through memorization (Clements and Battista, 1992) and although geometry is taught at every class level, Turkey scored lower than the average on every learning domain (number, algebra, geometry, and data and chance) in TIMSS 2007, an international exam. In addition, Turkey had the lowest average in geometry learning. This result requires reviewing geometry teaching in Turkey (TIMSS, 2011). In addition, Clements et al. (1999) state that teachers should help and guide students when classifying shapes into appropriate categories and telling them why shapes do not belong to certain categories when students are learning the properties of geometric shapes and being informed about knowledge on the components that make up shapes. In this respect, it is important to investigate how basic concepts are perceived and taught

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by preservice teachers during the pre school period when students come across geometric concepts for the first time.

THEORICAL FRAMEWORK

Geometry instruction during the pre school period

Students come across geometric concepts for the first time during pre school period. The curriculum of the pre school period entails four basic geometric shapes: circle, triangle, square and rectangle (MNE, 2006). During this period, geometric shapes are taught in order to help students recognise objects around them, and especially see and state the similarities and differences between the shapes of objects (Charlesworth, 2012). Clements and Sarama (2009) state children learn circle at the ages of 4 to 6; triangle, square and rectangle at the ages of 3 to 5, and the number of sides at the ages of 5 to 6. Instead of giving direct instruction during the ages of 3 to 6, children are made to develop an opinion on circle, triangle, square and rectangle by investigating and manipulating the shapes. By this way, children can recognise the shapes by their names and this happens according to a prototype (common examples) (Clement and Sarama, 2000; Hannibal, 1999). Aslan and Aktaş-Arnas (2004) state in their study that kurtosis, skewness and position affect children's decisions for classifying geometric shapes. During this period, children should be exposed to different prototypes of geometric shapes in order for them to internalise the shapes. According to Dienes' Mathematical Variability Principle when developing a mathematical concept involving variables, the variables should be kept constant and the perceptual variables should systematically be varied so that students can grow the concept better. For example, the sizes of angles, lenghts of sides and position of a geometric shape can be changed (Olkun and Uçar, 2007). Hannibal (1999) states that when triangle is taugth to children they should not be told that it is like an open triangle as used in music classes. In addition, they should not be told that triangles have three corners: two of them are below and one of them is above. According to NCTM (2000), teachers should use mathematical language correctly when presenting to children. Clements and Sarama (2000) stated that teachers telling children incorrect statements regarding concepts may cause students to learn them incorrectly. In addition, teachers are expected to have good mathematical knowledge and understand the topics they teach (NCTM, 2000; Shulman, 1986). In this respect, teachers' SMK and PCK are very important for teaching mathematics.

NCTM explained standards in mathematics teaching in terms of knowledge, skills and meaning from pre school period to 12th grade in details. In geometry, pre-K through grade 2 all students should:

i) Recognize, name, build, draw, compare, and sort two- and three-dimensional shapes;
ii) Describe attributes and parts of two- and three-dimensional shapes;
iii) Investigate and predict the results of putting together and taking apart two- and three-dimensional shapes (NCTM, 2012).

In Turkey, Ministry of National Education prepared a pre school curriculum including geometric shapes and objectives to be taught to pre school children of 36 to 72 months. The definition of pre school curriculum which includes aims and objectives regarding geometric shapes reads like this: "this program, designed for children aged 36 to 72 months old, is a developmental one". That is, it aims to improve all developmental domains of children. The program mentality is holistic and the curricular approach is spiral (MNE, 2006). In terms of the approach, the rationale is that it is difficult to acquire the same aims and objectives with one activity or in the same day; therefore, the objectives take place repeatedly (MNE, 2006). When the objectives in the pre school curriculum regarding geometric shapes are scrutinized they look like the following in general:

Objective*:* To recognise geometric shapes. The child can,

i) Tell that every object has a shape;
ii) Show objects that look like circle, triangle, square and rectangle;
iii) Create different models by using circle, triangle, square and rectangle;

Geometric shapes will be easily and naturally acquired by children through the learning situations and learning settings prepared in line with the objectives in the curriculum as well as through playlike activities, children's active participation and their own construction of knowledge (MNE, 2006). In addition, similar objects in close vicinity can be used in order to teach aims and objectives regarding geometric shapes. Children can be asked to name objects around them (Sarama and Clements, 2006). During the pre school period teachers can ask children to state the names of certain geometric shapes or children can show the shape that was described aurally by the teacher without seeing the actual model (Aktaş-Arnas, 2006). Teachers can find objects in class that have geometric shapes and can ask about their shapes to children. Teachers can create a model out of a card and can ask children to create the same model. The difficulty level of the models can be increased or children can be asked to create original models (Kandir and Orçan, 2010).

It is important to employ various methods and technigues in order to teach geometric shapes during the pre school education and relate them with other activities

in the program. In this respect, in order to teach geometric shapes during the pre school period, free time activities, games, music, drama, science and nature, language, art, reading and writing preparation activities can be used (Erdoğan, 2010). In order to teach geometric shapes during this period several methods and strategies such as cooperative learning, demonstration, story telling, question and answer, and discussion can be incorporated into activities (Güven, 2010). In order to evaluate how much children learned about geometric shapes during the pre school period, some data collection and evaluation methods such as observation, asking questions, checking students' products, collecting data from adults, performance evaluation, teachers' notes, checklists, scales and rubrics can be used (Buldu, 2010). In addition, when preparing activities to teach geometric shapes it is also important to define shapes correctly in mathematical terms, and also take children's developmental stage into consideration (Hannibal, 1996). In this case, teachers' knowledge of geometric shapes and how they will reflect this knowledge onto their students gain importance.

Teachers' knowledge

In any educational system, one of the most important factors that determine the quality of education is teachers. It is important to investigate how teachers should be given the types of knowledge that they should have in order to increase the quality of teaching. Shulman (1986), based on what teachers should know and what they should do in class categorized types of knowledge that teachers should have into seven categories: subject matter or content knowledge, general pedagogical knowledge, curriculum knowledge, pedagogical content knowledge, knowledge of learners and their characteristics, knowledge of educational contexts, and knowledge of educational purposes. Grossman (1990) classified knowledge that teachers should have into four types: subject matter knowledge, general pedagogical knowledge, pedagogical content knowledge, and knowledge of context. This research focuses on two of these types namely, subject matter knowledge (SMK) and pedagogical content knowledge (PCK).

SMK is knowledge that teachers have regarding the subject matter and the concepts and information regarding the field. In addition, SMK consists of both substantive knowledge (the key facts, concepts, principles and explanatory frameworks in a discipline) and syntactic knowledge (knowledge that is used to determine whether concepts and facts in a discipline are correct or not, and reliable or not) (Shulman, 1986).

PCK has been described as knowledge used to transform subject matter content into forms that are more comprehensible to students (Grossman, 1990; Marks, 1990; Shulman, 1986, 1987). Shulman (1986) stated that PCK is the subject-specific instructional strategies, instructional representations, and teachers' knowledge of students' understanding. Grossman (1990) categorized PCK into four domains: the teacher's knowledge regarding learners' comprehension and perception, the teacher's knowledge of curriculum and curricular materials, the teacher's knowledge of instructional strategies and the teacher's conception about the purposes of teaching a subject matter. Frameworks regarding PCK in the literature were compiled by the study of Bukova-Güzel (2010) and a PCK framework was reached:

i) Knowledge of teaching strategies and multiple representations (appropriate activities, real life examples, different instructional strategies, different representations-graphics, tables, formulas etc).
ii) Knowledge of learner (knowledge of students' prior knowledge, knowledge of possible student misconceptions, knowledge of student differences).
iii) Curricular Knowledge (the elements of mathematics curriculum, the varieties of instructional tools in mathematics curriculum, the instruments to measure student's learning, horizontal and vertical program knowledge for a topic.

Teachers do not emphasize geometry enough during preschool when teaching mathematics because they do not have enough accumulation of knowledge regarding geometry (Welter, 2001). Similarity, Şimşek et al. (2012) have stated that preservice mathematics teachers' subject matter knowledge is insufficient in geometry. In this respect, while pre school preservice teachers are being instructed it is important to focus on developing their SMK and PCK. It is stated in the literature the relationships between teachers' mathematical knowledge and teachers' effectiveness (Rockoff et al., 2008; Aaronson et al., 2007) and relationships between teachers' pedagogical content knowledge and the quality of teacher-student interaction (Baumert et al., 2010). Besides, if teachers have strong mathematical knowledge, they may encourage students to think productively in mathematics lessons (Charalambous, 2010).

In order to develop SMK of preservice teachers, firstly, it is important for them to determine how much they know about the basic concepts, and in order to develop PCK they need to investigate appropriate instructional strategies for the subject that they will teach, and they also need to know which parts of the subject that students have difficulties in Lederman et al. (1994). In addition, the effectiveness level of a teacher in helping his students' understanding of a topic cannot go beyond his own understanding of the topic (Hill et al., 2005; Ma, 1999; Murphy, 2012). In line with this, the objective of this study is to investigate SMK and PCK of preservice pre school teachers regarding geometric shapes. In addition, this study addresses and tries to evaluate the present situation of preservice teacher education and teaching practice lessons, and the effects of lessons in the teacher education programs on the development of SMK and PCK of preservice pre school teachers. All in all, this study

is expected to contribute to the education of preservice pre school teachers.

This study aimes at answering the following research questions:

1. What is the situation of subject matter knowledge of pre school preservice teachers regarding geometric shapes?
2. What is the pre school preservice teachers' situation of knowledge of instructional strategies and knowledge of multiple representations regarding geometric shapes?
3. What is the pre school preservice teachers' situation of knowledge of learners regarding geometric shapes?
4. What is the pre school preservice teachers' situation of knowledge of curriculum regarding geometric shapes?

MATERIALS AND METHODS

The study aims at investigating how pre school preservice teachers implement their SMK and PCK in class; therefore, case study method, a qualitative method, was used. Case study method examines the phenomenon within its own real-life framework where the boundaries between phenomenon and the context in which it takes place are not clearly set; and multiple sources of data are used for investigation (Yin, 1984). In this context, case study method was employed in order to examine pre school preservice teachers' SMK and PCK regarding geometric shapes within real-life class contexts and describe the situation in details.

Participants

The participants were chosen by deviant case sampling, a type of purposeful sampling. Deviant case sampling provides a small number of, but at the same time rich cases to investigate for in-depth study (Yildirim and Şimşek, 2008). This study was conducted with two senior year students (1 female, 1 male) studying at department of pre school education at a state university where they were taking teaching practice (practicum) class. Instead of using participants' names, this study used PT1 for the preservice teacher who has a high academic achievement level (3.50 and above) and used PT2 for the preservice teacher who has a low academic achievement level (2.00 to 2.49). When the research group was chosen, their undergraduate level grade point averages for seven semesters and their grades for 'Teaching Mathematics' lesson were considered. During the undergraduate level education preservice teachers studying at the department of pre school education did not take any lessons in mathematics subject matter per se, and yet they took majority of PCK classes such as Instructional Principles and Methods, Teaching Mathematics, Instructional Technologies and Material Design, Instructional Methods for Pre School Education I and II, Measurement and Evaluation. They also have been attending teaching practice program at designated schools under the leadership of two mentors for two semesters. One of the researchers is one of their mentors at the university.

Instruments

Triangulation was employed in order to increase validity. The literature suggests there are different types of triangulation such as data triangulation, investigator triangulation, theory triangulation and methodological triangulation (Patton, 2002; Cohen et al., 2000). This research employed data triangulation method in order to collect different and in-depth data on preservice teachers' SMK and PCK. Interviews, written documents and observation methods were used to collect the data. The explanation regarding them is as follows:

Semi-structured interviews

Two interviews were conducted with the preservice teachers. During the first and second interviews, the preservice teachers were asked 7 questions on an interview form in a semi-structured manner in terms of their SMK and PCK on geometric shapes. Each participant was interviewed in one-to-one manner and all interviews were audio recorded, deciphered carefully and written in detail.

Written documents

They are the lesson plans of the objectives in the curriculum regarding geometric shapes prepared for teaching 60 to 72 month old students. The plans, showing all the activities that they will use while teaching, were prepared by the participants who were asked to prepare them after the first interview before they teach their classes. These plans enabled researchers to determine the participants' ability to plan their lessons in order to teach new concepts to students and also enabled the researchers to evaluate whether their lesson plans match with the way they teach their lessons.

Observation

The participants were observed when teaching geometric shapes to 60 to 72 month old students in a group of 20 in a class and their half day long sessions were video recorded. These video recordings were put into writing afterwards.

Procedure

Data were collected in May during 2009 to 2010 Spring Semester for a three weeks period. Before class observations, the first interview session was conducted with preservice teachers regarding geometric shapes and they were asked to prepare their lesson plans. They were asked to implement their lesson plans in half a day period and their teaching sessions were video recorded. After they taught in class, the preservice teachers were asked the same questions again during the second interview sessions.

Data analysis

The data were analyzed and interpreted through content analysis, a qualitative analysis method. A framework was constructed from the research questions, the context of the research and dimensions under three data collection devices. In qualitative research, instead of "internal validity", the term "credibility" was used; instead of "external validity", "transferability" was used; instead of "internal reliability", "dependability" was used; and instead of "external reliability" the term "confirmability" was preferred (Yildirim and Şimşek, 2008). Internal validity of the research was achieved through triangulation. Externel validity was achieved through direct quotations and interpretation of data. In order to achieve respondents' validation, the interviews and their video recordings which were carefully written down were shown to the participants to scrutinise, and themes and listings of codes created by both researchers individually were compared after the study ended. In the study, SMK was evaluated based on the themes defined (definitions of the shapes) and PCK was also evaluated based on the main themes defined under PCK's framework: "knowledge of the instructional strategies and multiple representation", "knowledge

Table 1. Preservice teachers' interview results regarding definitions.

Parameter	First interview	Second interview
PT1	*Circle:* is round.	*Circle*: is round.
	Ttriangle has three vertices, all of the vertices are equal.	*Triangle*: has three vertices, all of them are equal to each other.
	Square: have four vertices, all four vertices are equal.	*Square:* has four vertices, all four vertices are equal to each other.
	Rectangle: has two long, two short sides.	*Rectangle:* there are two long, two short sides.
PT2	*Circle:* It is full area of circle.	*Circle*: It is full area of circle.
	Triangle: It is the connection of non linear three points	*Triangle*: It is the connection of non linear three points and it is a shape with three vertices and three sides.
	Square: has four vertices and four sides and the sides are equal to each other.	*Square*: has four vertices and four sides and the sides are equal to each other.
	Rectangle: has four vertices and four sides.	*Rectangle*: has four vertices and four sides.

of learners" and "knowledge of curriculum". The sub themes of PCK's main theme are:

knowledge of instructional strategies and multiple representation

Method (direct teaching, demonstration...), technique (relating with daily life, question and answer, group work...), different representations (computer media, usage of materials, fun, worksheets, different models)

Knowledge of learners

students' prior learning, misconceptions, individual differences.

Knowledge of curriculum

Aims, learning situations and evaluation.

After the study ended the lists of themes and codes prepared individually by both researchers were compared:

$$P = \frac{Na}{Na + Nd}$$

This formula was applied to the codes (Miles and Huberman, 1994).

P is the percent of consistency, Na is the consistency amount and Nd is the inconsistency amount. In order to secure the reliability of the codings, the interview results, video recordings and the written documents were coded again at different times and their percent of consistency was calculated. The percent of consistency for the first interview was 93%, and 96% for the second interview. It was 90% for the video recordings, and 95% for the written documents. The literature suggests that inter-coder agreement in qualitative data analysis should approach or exceed 90% (Miles and Huberman, 1994). In addition, the data collected from all three instruments (interviews, written documents and the observations) were found to be consistent.

FINDINGS

The findings are discussed with reference to the four reseach questions and the data collected from the interviews, lesson plans, and observations regarding preservice teachers' SMK and PCK are evaluated below.

R.Q.1. What is the situation of subject matter knowledge of the pre school preservice teachers regarding geometric shapes?

In line with this research question the preservice teachers were asked whether their subject matter knowledge is enough to teach geometric shapes during the first and second interviews, and they were also asked to define circle, triangle, square and rectangle. The properties of geometric shapes are constructed through definitions that make up the axiomatic system. A definition is usually the most limited subset of necessary and sufficient characteristics in order to define a concept. This way, the definition can be used as a criteria to classify examples and non examples (Charalambos, 1997). Both of the preservice teachers stated their SMK is enough.

However, PT1 (the preservice teacher with high academic achievement level) could not define the geometric shapes during the first and the second interviews and she was observed to have some misconceptions regarding them. The definitions of PT2 (the preservice teacher with low academic achievement level) were not fully correct and included some conceptual mistakes and missing points. Some examples of the answers given by both of the preservice teachers are seen in Table 1.

As seen in the table, PT1's defining circle as round may

Figure1. Free time activity of PT1.

cause a misconception because every round shape may not be a circle. Also, in order to define triangle, sides and lines which are the defining features of the concept were not mentioned at all. Also the statement “its three vertices are equal” is not a logical explanation. A similar expression was used when defining square as well. When defining rectangle, the participant did not mention that long and short sides are equal and the angles are 90. Unfortunately, PT1 repeated these definitions in the lesson plan which was prepared after consulting several resources, and during the second interview which took place after teaching in class where she implemented the lesson plan. Moreover, the preservice teacher was observed to have reflected her missing knowledge and misconceptions both on the lesson plan and the class teaching. PT2, on the other hand, said during the first interview, ‘circle is round and its inside is full’, and this is a correct approach to define it. When he is defining triangle in the first interview, he did not mention how non-linear three points intersect since their intersection can also be curvilinear. Similar to PT1, PT2 did not mention the defining properties of a triangle. His definition of square points out rhombus and his definition of rectangle can point out any quadrilateral; therefore they are not conceptually correct. After the preparation of lesson plan and class presentations definitions of circle, square and rectangle given by PT2 were not changed, and yet his changing the definition of triangle in a conceptually positive way was evaluated as a positive development. Nevertheless, similar to PT1, PT2 also did not reflect the conceptual information (defining properties-lines, angles, and non-definitive properties- kurtosis, skewness and position) of the shapes fully during teaching. In conclusion, SMK of PT1 and PT2 regarding geometric shapes can be considered insufficient.

R.Q.2. What is the pre school preservice teachers’ situation of knowledge of instructional strategies and knowledge of multiple representations regarding geometric shapes?

In this the preservice teachers were asked during the first and second interviews: “How do you teach geometric shapes?”. The followings are their thoughts mentioned during the first interview:

> First of all, I explain the geometric shapes orally. Then, I show them the shapes. I ask children to look around and find the geometric shapes in the objects they see and ask them to construct the shapes through the tracing lines worksheets (PT1).
>
> I teach by showing similar shapes (PT2).

During the second interview, both preservice teachers said they would teach them the same as in their lesson plans which they prepared and presented in class.

When the lesson plans of both preservice teachers were compared, the plan of PT1 was found to include more activities than the lesson plan prepared by PT2. Both of them were found to have written the objectives, explanatory information and activities to achieve their goals in details and without any missing points. In addition, both preservice teachers tried to mention the definite features of square and rectangle partially in their plans although they did not mention the definite features of all the shapes. However, PT1 reflected her conceptual mistakes that she made while defining the geometric shapes in her lesson plans. PT1 had six activities and PT2 had five activities in his lesson plans. These activities, due to the order of their presentation, also provide information on whether or not they facilitate the teaching of concepts to children.

The following are the activites and the applications of preservice teachers: the first activity of PT1 was “Free time activity” during which she gave several geometric shapes to the children and asked them to put the shapes together in order to create a new shape or object. During the process she asked about the shapes in children’s hands and tried to elicit their prior learning (Figure 1).

The second activity of PT1 was “Turkish Language Activity”. Before she started this activity she placed tables in a "U" shape. During this activity she read a letter to the children. The letter wanted the children to find the shapes that were missing. PT1 asked the children to bring her any objects that looked like circle, triangle, square and rectangle in the class that are missing. Then she defined the geometric shapes. But when defining triangle, she showed the sides and said it has three vertices. Similarly, when defining the rectangle, she showed the sides and said vertices. It was observed that the same situation regarding definitions that were made by the preservice teacher during the first interview was reflected during the class presentation. This situation made us think that she is mixing the concepts of ‘vertex’ and ‘side’. During this activity PT1 showed sample pictures of geometric objects in daily life via a computer. By doing this, she related the geometric shapes with daily life (Figure 2a). In addition, she showed which surfaces of the shapes look like which shape and sometimes she wanted the students to tell her the name of the shape.

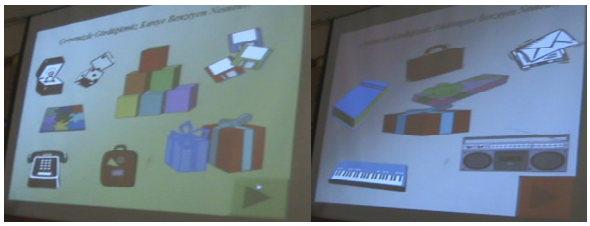

Figure2a. Turkish language activity of PT1.

Figure 2b. Turkish language activity of PT1.

Figure 3. Game activity of PT1.

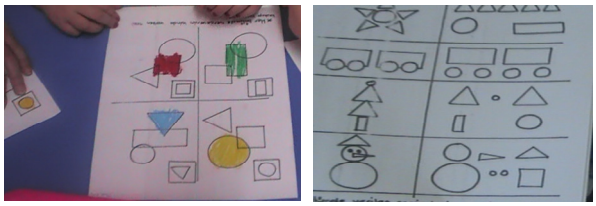

Figure 4. Worksheets of PT1.

Figure 5. Free time activity of PT2.

PT1 asked the pupils questions regarding shapes that have different angles, sides kurtosis, skewness and position (Figure 2b). These questions enabled the children reinforce the properties of the geometric shapes.

At the end of this activity PT1 asked the students simple riddles regarding the geometric shapes. This was one of the longest activities prepared by PT1 and her interaction with the students was very good. She tried to pay attention to every child personally. Therefore PT1 was good at classroom management.

PT1, during the third activity, that is the "Art Activity" distributed geometric shapes of different sizes cut out from the thick papers of different colors to the children and asked them to make puppets. She asked each child about the name of the puppet character that he created, the features of the character and its name. PT1 stated this would help the children to internalise the geometric shapes.

PT1's fourth activity was "Game Activity". There were three games during this activity and she named them as warm up, active and relaxation. During the warm up she asked the children to finish a pattern that she prepared earlier. During the active game, different geometric shapes were hung around children's necks and they danced with music and when the music stopped the children were asked to go the designated areas where the same shapes were placed. During the relaxation period, PT1 put the children into groups and asked them to create the geometric shapes by using their bodies and the ropes given (Figure 3).

PT1 made the children play games with the geometric shapes and they had fun during the game activity.

PT1's fifth activity was music and she taught the children a song in which the names of the geometric shapes were mentioned and they sang together.

PT1's final activity was for "Preparation to Reading and Writing" and she gave two worksheets to the children and asked them to color the shapes that were asked (Figure 4).

PT1 enabled the children reinforce the geometric shapes through this activity. The final activity shows that the geometric shapes were learned because each child was able to do what he was asked in the worksheets successfully by himself.

The first activity of PT2 was "Free time Activity" and he gave some time to the children to play with any toys they wanted to play with (Figure 5). During this period, PT2 did not mention anything about geometric shapes.

The second activity of PT2 was "Turkish Language Activity" and he told a short story about sides and vertices of the shapes to the children by showing them puppets made of the geometric shapes (Figure 6). Unfortunately, similar to PT1, PT2 also reflected his conceptual mistakes regarding the definitions that he made during the first interview to his presentation. Especially during this activity when PT2 was introducing the puppets he said "A rectangle has four sides and four

Figure 6. Turkish language activity of PT2.

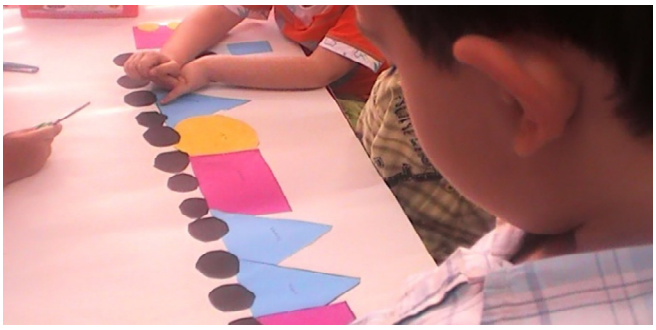

Figure 7. Art activity of PT2.

vertices. The sides are not equal". This statement may cause a misconception in children. After the introduction of the geometric shapes he asked the children to show objects in the classroom that looked like the geometric shapes he showed them. Similar to PT1 he tried to relate the concepts with daily life.

PT2's third activity was the "Music Activity". Different from PT1's music activity, PT2's made the pupils listen to a song mentioning not only the names of the geometric shapes but also the properties of sides and angles of geometric shapes. He then made the students sing only the parts about circle and triangle. If he had taught the students the whole song as a reinforcement activity, it would have been a more effective activity.

The fourth activity of PT2 was "Play Activity". During this activity, he chose one pupil, made him close his eyes and gave him one of the geometric shapes, making him tell its name by touching it. After the majority of the children played this game he moved onto the "Art Activity". In the fifth activity he asked the pupils to cut colored papers onto which geometric shapes were drawn and the children pasted these shapes on paper in order to form a "shape train".

Both preservice teachers tried to help the children to learn the shapes in the activities generally by relating the shapes with daily life (Figure 2a), presenting the shapes visually (Figure 2b, 6), and making the children construct new models with the shapes (puppets and train, Figure 7). There are differences in the ways both preservice teachers teach their lessons also. The way PT1 teaches in general is different from PT2 in that her each activity was different from the other and the order of her presentation facilitates students' learning of the subject. PT2, on the other hand, has less activities than PT1 and this reduced the opportunity of all children participating in the activities. Also contrary to PT1, in PT2's activities there were not examples of shapes of different sizes and of different locations. He only showed the one type prototypes of the shapes and he did not allow the children reinforce the properties of the geometric shapes much. In this respect, PT2's teaching did not facilitate the children's learning. In addition, PT2 was observed not to do any activity to asses whether the children learned the shapes or not.

In conclusion, PT1, by making the concepts concrete and relating them with daily life, and also designing different activities (games, music, art, Turkish-language etc.) and using multiple representations (different materials, computers) to teach, better reflects the two sub domains of PCK, namely instructional strategies and multiple representations.

R.Q.3. What is the pre school preservice teachers' situation of knowledge of learners regarding geometric shapes?

PT1 making an activity with the geometric shapes to address the children's prior learning during the free time activity shows she knows a component of learners' knowledge. PT2, on the other hand, did not do any activity at the beginning of his class to elicit the children's prior learning. The preservice teachers were also asked during the first and the second interviews: "What kind of misconceptions might children have regarding the geometric shapes?" and "What would you do to avoid children's forming misconceptions?". Both preservice teachers stated children might confuse rectangle with square during the first and the second interviews. However, neither of the preservice teachers mentioned that children experience problems in recognising shapes when the sizes and the locations of triangle, square and rectangle were changed and they can mix up ellipse with circle (Aktaş-Arnas, 2006). In conclusion, the preservice teachers may be said to have some knowledge on misconceptions, a category of learners' knowledge. PT1 tried to show different sizes of the shapes on different locations during teaching in order to avoid formation of misconceptions. Table 2 summarizes the opinions of preservice teachers regarding what they could do in order to avoid the formation of misconceptions.

As seen in the table, the preservice teachers considering their experiences gained from their teaching in class, they made suggestions to relate the instruction with daily life, design activities suitable to learners' ages, make activities interesting and the use of different games

Table 2. Preservice teachers' views regarding avoiding the formation of misconceptions.

Parameter	First interview	Second interview
PT1	I want them to give examples of the geometric shapes in the vicinity. I ask them questions and explain the points they did not understand.	I relate the geometric shapes with daily life. I pay attention to design the activities suitable to they ages and pay attention to individual differences.
PT2	I teach the shapes starting from the simple to more complex.	I relate the objects around them with geometric shapes. I try to not to make boring activities when teaching the concepts and try to use different games.

Table 3. Preservice teachers' views regarding evaluating children.

Parameter	First interview	Second interview
PT1	I evaluate them by asking questions when they are playing.	I evaulate them basing on worksheets, use of computers, and forming the geometric shapes by using their bodies.
PT2	I can show the shape and ask them say its name to evaluate.	I evaluate them when they can show the correct shape.

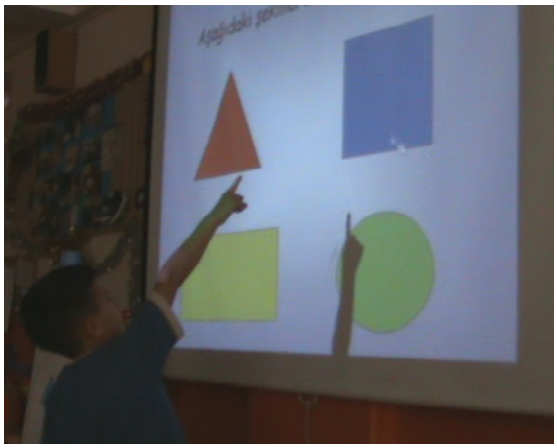

Figure 8. Sample evaluation activity.

and in order for students not to form misconceptions. The preservice teachers implemented their suggestions in their lesson plans and class activities. Also they tried to consider especially children's possible misconceptions (one of a component of learners' knowledge) at least partially. It is thought that expecting more from them would be too difficult. This is because SMK of the preservice teachers was found low and by virtue of that their misconceptions were reflected on their class presentations. The preservice teachers also varied the types of activities in order to avoid problems created by the individual differences among the children. Especially PT1 was found more succesful in this as mentioned earlier.

As a conclusion, it can be said that PT 1 has learners' knowledge to a great extent and PT 2 has learners' knowledge partially.

R.Q.4. What is the pre school preservice teachers' situation of knowledge of curriculum regarding geometric shapes?

The pre school preservice teachers were asked during the first and second interviews: "what are the objectives in the curriculum regarding geometric shapes?" and "how do you evaluate whether the pupils achieved the objectives or not?" Both preservice teachers stated that they did not know the objectives in the curriculum during the first interview and they said their prediction would be "to be able to state the name of the geometric shape". After they prepared a lesson plan after presenting in class they were able to state all three of the objectives in the curriculum during the second interview. It is thought that both preservice teachers referred to the curriculum in order to prepare their lesson plans and they learned the objectives.

When activities to teach the objectives in the curriculum (the play based activities in preservice teachers' lesson plans, the children's active participation and materials they used) were considered the preservice teachers were found to have tried to fullfill the requirements of the desired approach in the curriculum.

As Table 3 shows PT1 mentioned different evaluation strategies and applied them (worksheets-Figure 4; use of computers-Figure 8; use of body-Figure 3) in the activities after the instruction ended. For example, one of the activities that PT1 prepared on the computer in order to asses whether the students learned the geometric shapes or not is shown in Figure 8.

In the figure above PT1 asks the students to show the square.

PT2, on the other hand, has not changed his approach much. He pointed out the students' telling the names of the shapes during instruction and he did not do any acti-

vity to asses the students. The reason of this might be the preservice teacher's lack of knowledge and experience on different approaches regarding evaluation. Consequently, we can state that the preservice teachers have partial knowledge of the curriculum.

DISCUSSION AND CONCLUSION

This study investigated the SMK and PCK of two preservice pre school teachers on geometric shapes and some conclusions were drawn.

The first conclusion is that preservice preschool teachers have some missing points in SMK as well as some misconceptions regarding geometric shapes. In relation to substantive knowledge, neither of the preservice teachers had fully appreciated a definition of geometric shapes. As stated in the literature, teachers do not have sufficient knowledge of definitions (Fujita and Jones, 2007). In the study, they did not use mathematical language effectively. At the same time, they were found not to have syntactic knowledge. If preservice teachers had had that knowledge they would have been aware of the misconceptions they stated. Consequenly, this was reflected on their activity plans and their class teaching. As Murphy (2012) stated there is a direct relationship between a teacher's comprehension level of mathematical concepts and developing her students' level of understanding of these concepts.

Another result of the research is that preservice teachers paid attention to relate the geometric shapes with daily life and they incorporated different activities such as games, music, art and language while teaching. As stated in the literature children's interaction with their environment and geometric figures using real life objects are important (Dickson et al., 1990; Inan and Dogan-Temur, 2010). Similarly, in this study preservice teachers can help their students' learning concepts by relating them to daily life. Akman (2002) stated the more various the materials get the easier it becomes for children to understand mathematical concepts, geometric concepts and other concepts. PT 1 provided this variety more during teaching. In addition, PT1 mentioned non-definitive features of the geometric shapes in the activities. PT1 also used computers in order to show examples of the geometric shapes in daily life and also asked evaluative questions on the computer. The literature about the use of computers when teaching children states that although there are some critics, the majority of the research shows that computers can be very powerful tools because they encourage young learners to learn in different and dynamic ways (Clements et al., 1993; Yelland, 1999). Clements and Sarama (2009) mentioned children's learning of the concept of shapes will be enriched if different examples, non-examples, arguments about shapes and their features, and the variety in categories of shapes will be added to children's learning environment. In addition to mentioning definitive features of shapes (such as sides, corners, angles etc.), focusing on non-definitive features of shapes (such as kurtosis, skewness and position) can support children's learning. As Topbaş (2010) stated, not giving non-definitive features of geometric shapes on every class level may lead to students making mistakes in understanding and comprehending the concepts.

The findings of the study regarding the learners' knowledge of the preservice teachers show that PT1 has learners' knowledge to a great extent, whereas PT2 has learners' knowledge partially. It was found that the preservice teachers have no full knowledge regarding possible students' misconceptions. In addition, PT2 did not ask about the children's prior learning and he was more inefficient about individual differences. In order to avoid this, it will be beneficial to inform preservice teachers about possible student's misconceptions during their undergraduate studies.

Findings regarding the preservice teachers' knowledge of curriculum show that they have knowledge of curriculum to some extent. Especially, they were observed to have knowledge regarding the objectives in the curriculum after they taught in class. While PT1 employed different approaches for measurement and evaluation PT2 is thought to have missing knowledge about measurement and evaluation becuse he did not mention different approaches for measurement and evaluation and also did not implement them.

The results of the research suggest that it is important to focus on preservice teachers' SMK that they have while they are being instructed. Their missing knowledge about the subject or misconceptions they might have should be cleared. As stated by many researchers, the benefit of instruction is limited to the instructors' knowledge (Hill et al., 2005; Ma, 1999; Murphy, 2012). In addition, in order to develop preservice teachers' PCK during their undergraduate studies, for example, they should be informed about different instructional methods, children's developmental levels, their possible mis-conceptions, measurement and evaluation instruments and implementation of different represantations of geometric shapes. In addition, keeping the importance of experience in mind (Leinhardt and Smith, 1985), preservice teachers' lesson plans which enable them to implement what they learned at classes and which were prepared to be implemented at school based on applications should ensure that they serve their purpose in terms of SMK and PCK.

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